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THE U. S. NAVAL OBSERVATORY ECLIPSE EXPEDITION TO SUMATRA.

By Heber D. Curtis.

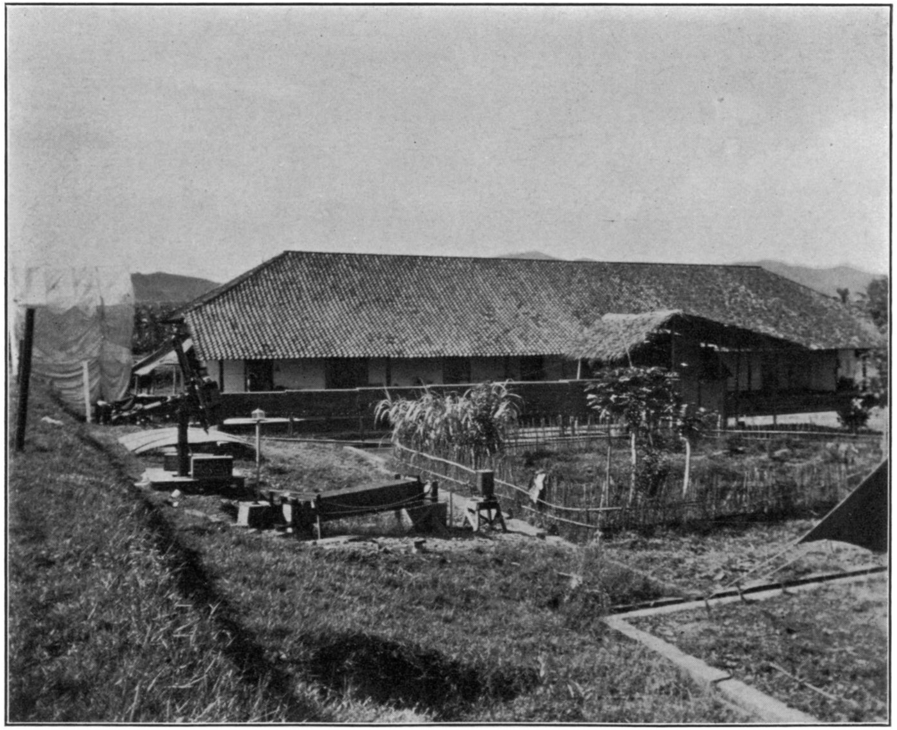
In pursuance of the liberal and progressive policy which provided for the observation of the eclipse of May, 1900, and for numerous extensive expeditions in the past, the Government late in 1900 appropriated the sum of $10,000 for an expedition to observe the total eclipse of May 18, 1901, in Sumatra. Owing to the exceedingly limited time, some of the special apparatus was necessarily constructed in great haste; but everything was ready by February 7th, a date which would give none too much time for the long journey and the equipment of the camps.

The Naval Observatory party proper numbered eleven members, namely: Professor A. N. Skinner, U. S. N., Director; Professor W. S. Eichelberger, U. S. N., Assistant Astronomer, F. B. Littell, Mr. George Peters, Mr. L. E. Jewell, and Mr. W. W. Dinwiddie, of the Naval Observatory; Professor E. E. Barnard, of Yerkes Observatory; Dr. S. A. Mitchell, of Columbia University; and Dr. W. J. Humphreys and the writer, from the University of Virginia. Associated with the Naval Observatory on the trip was the Smithsonian party — Mr. C. G. Abbott, and his assistant, Mr. Paul A. Draper, of Washington. The distance to be traveled was nearly 14,000 miles by the route selected, the cost of which would have eaten very heavily into the available appropriations had not the party, through the courtesy of the Secretary of War and the Secretary of the Navy, been carried between San Francisco and Manila on a Government transport, and from Manila to Sumatra on the U. S. gunboat "General Alava."

San Francisco was left on February 16th, on the U. S. A. T. "Sheridan." The month-long sea-trip to Manila was pleasantly broken by a few days at Honolulu. Here we enjoyed the generous hospitality of the Hawaiian Philosophical Association. Many of our most pleasant memories of this garden-spot of the Pacific are due to their thoughtfulness and courtesy. The charms of the sail southward through the tropics will not soon be forgotten by any of the party. Some industrious astronomers busied themselves with computations. Frequent conferences of all the members were held to deliberate on the methods to be followed and results hoped for in Sumatra. Occasionally the land itself came up for discussion, and it was on one of these occasions that the reading from various books of travel of highly colored passages with regard to the serpents of the East Indies brought it about that these conferences were henceforth known to the laity as meetings of the "Snake Club." Thanks to several energetic young officers, other diversions were not wanting; two minstrel shows, several lectures and addresses, a dance, a tug-of-war and two spirited boxing tournaments among the soldiers varied the monotony, and all short-comings were condoned in the Mid-Pacific. Consul WILLIAMS, formerly stationed at Manila, but now at Singapore, was one of the passengers on the "Sheridan," and it was through his kindness that after reaching Manila we were taken about the bay in a Government launch over the track that DEWEY followed, while the Consul himself, who was on the bridge with DEWEY, told us many interesting details of the battle and pointed out the forlorn wrecks of the Spanish war-vessels.

The distance from Manila to Padang, Sumatra, is about 2,200 miles, and this portion of the trip occupied us ten days, which passed quickly enough in the warm and many-hued waters of the China and Java seas, past interminable island-continents that the geographies of our younger days represented as apparently of equal area to the Bahamas. Both going and returning through the Straits of Sunda, we passed within less than a mile of Krakatoa, where Verlaten and Lange islands still show the former extent of Krakatoa before its tremendous eruption.

On April 1st we enjoyed the astronomical novelty of a vertical Sun. On this day, at apparent noon, the Sun was only four minutes of arc from our zenith. I took a sextant and, bringing the Sun into coincidence with the horizon, swept the entire circle of the horizon without having Sun and horizon leave the field of the sextant. On the "Alava," also, we went through the time-honored ceremony of "crossing the line," an interesting and laughable rite of sailing-ship days now not frequently seen. Father and Mother Neptune and their motley crew "came aboard" to hold their royal equatorial court. A large tank of salt water was improvised from a canvas sea-anchor. All tyros on board must needs be presented, and several astronomers were among them. Neptune's doctor administered a soap pill; the ace was lathered with a vile mixture of red-lead and molasses;



THE 61½-FOOT TELESCOPE. WITH INTRAMERCURIAL CAMERA SHELTER IN BACKGROUND, SOLOK.

then followed a none too gentle shave with a two-foot wooden razor in the hands of Neptune's barber, a sudden twist by the stalwart jackies, and the victim made room for the next culprit by a beautiful back somersault into the salt-water tank.

It was nearly two months after leaving Washington that we finally cast anchor in the beautiful land-locked harbor of Emmahaven. The meteorological reports of the Dutch Government had been carefully studied, and Solok on the Padang plateau had already been selected as the chief station. After a few days spent in reconnoitering, the members were soon at the respective stations. Three stations were selected, well separated from each other and from the camps of other parties — Solok, Sawah Loento, and Fort de Kock. The first two are over one thousand and the last named nearly three thousand feet above sea-level, and are situated from fifty to eighty miles from Padang.

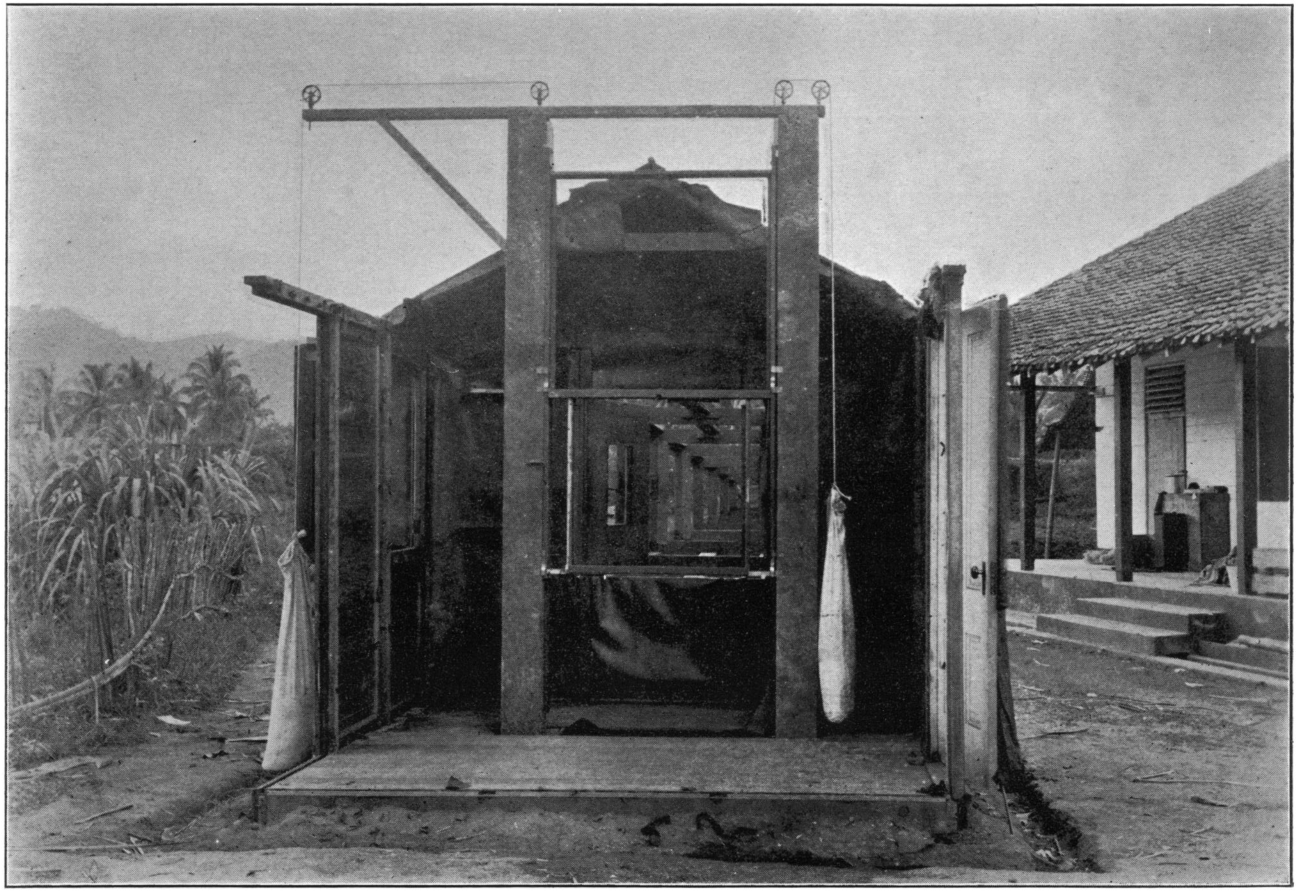
Solok was thirty-one miles from the central line; it was impracticable to go nearer the middle of the eclipse track, except on the coast, and stations were already chosen there by other parties. Alahan Pandjang, very near the central line, had been considered. It lies some thirty-five miles south of Solok, and is reached by an excellent road; but as our heavy equipment would have had to be transported there on the backs of coolies, it was decided that the increased advantages of this site would not warrant the time and the expense necessary to overcome the difficulties of placing a camp at this spot.

Fort de Kock, the northern station, was about seven miles south of the northern edge of the shadow, and the duration of the total phase at this point $2^m 40^s$. Here it was purposed to devote efforts particularly to the spectrum of the flash and inner corona and photographs of the inner corona with special reference to the polar streamers. Professor W. S. EICHELBERGER was in charge of this camp. Dr. W. J. HUMPHREYS here employed the 21½-foot concave grating belonging to the University of Virginia, while Mr. PETERS had charge of the forty-foot camera,— the lens, the property of the Naval Observatory, being the one used by Professor STONE in May, 1900, at Winsboro, N. C. In this instrument no plate-holders were used, but the plates placed and held against an adjustable frame placed at the focus.

Sawah Loento is a little town surrounded by mountains on all sides and is near the great government coal-mines. It is the southern terminus of the Sumatra Government Railroad, which was built primarily to bring the coal from these mines to the sea-coast. The coal is of very fair quality, and the mines are remarkable chiefly for the thickness of the deposits, one seam, I believe, having the unparalleled thickness of forty-two feet. The labor is entirely convict. The Dutch Government, with characteristic thrift, transports its Sumatra offenders to Java and the Javanese to Sumatra. These races hate one another so cordially that an escape of a convict is out of the question, and very little guarding is necessary. The curious little railroad was made to fit the country, not the country leveled and cut to make an easy road, and through the mountains engines of a composite type are used, on which supplementary gearing can be thrown into action on a heavy rack laid between the rails; the grades thus overcome are in several spots nearly 600 feet to the mile. It is an exceedingly picturesque road through the tropical growth of the mountains and the terraced rice-fields of the foot-hills; especially noteworthy is the beautiful Aneikloof gorge a few miles below the town of Padang Pandjang. The Naval Observatory station at Sawah Loento was located on the hillside about a mile from town and a few hundred feet above it, quite near the camp of the Massachusetts Institute of Technology. Dr. Mitchell here had a large-grating spectroscope and a six-inch lens of 104 inches focal length. He was assisted by Mr. René Granger, of Cartersville, Ga., who came independently via London to give his services to the party.

The main station was located at the village of Solok (Long., $6^h\ 42^m\ 36^s$ E.; Lat., 0° 47′ 17″ S.). Here Professor Skinner was particularly fortunate in securing for the eclipse camp a small fort which had been abandoned for about two years. It was about two hundred feet square and was surrounded by a wall, moat, and a *cheveau-de-frise* of wire tangle which effectually isolated the camp from the over-curious native. Along one side ran the large cement-floored barracks, which formed an excellent storehouse, and served also as sleeping quarters for four of the party, Hotel Talang, with a maximum capacity of six guests, being swamped by the influx of visitors. In one end of these barracks were located Mr. Abbott's constant temperature room for the bolometric work. The fort was well drained, and the former powder magazine made an excellent dark-room.

At this station were located Professor Barnard, with the



REAR VIEW OF THE 61½-FOOT CAMERA, SHOWING MECHANISM.

61½-foot camera; Mr. LITTELL, with a flat-grating spectrograph, and Mr. L. E. JEWELL, with a concave grating; Mr. DINWIDDIE, with a prismatic camera fitted with a large prism, loaned by the Smithsonian Institution; Dr. GILBERT, with a spectropolarigraph, loaned by Professor WOODS, of the University of Wisconsin; and the writer, in charge of a 7¾-inch lens of 114 inches focal length and a pair of large cameras mounted on a six inch equatorial.

Professor BARNARD'S instrument received its light from a large coelostat provided with electrical control. The details of the tube and house are seen in the photographs. The electrical control worked perfectly. His method of exposing the plates may be seen in the cut of the interior of the photographic house. Two pillars of 8×8 timber were set firmly five feet in the ground; between these ran smoothly a counterpoised framework with suitable guides and stops. The upper compartment of the framework held a 40×40 plate-holder; the lower held 30×30. The larger holder remained in the sliding frame during the eclipse. The various 30×30 holders could be very quickly slipped in and removed after exposure. At the proper time the frame was pulled down so as to bring the image of the Sun in the center of the 40×40 plate, and after the exposure the frame was pushed up for the remaining exposures on the 30×30 plates. The 40×40 plate, the largest ever exposed for astronomical purposes, received an exposure of two minutes and a half. To prevent excessive over-exposure of the inner coronal regions, a screen of about the size of the Moon's image (nearly eight inches) was fastened to a long wire handle. The edges of this screen were covered with absorbent-cotton so as to be fluffy and ill-defined, and in use it was kept constantly in motion over the image of the Sun on the plate. All plates were backed, and those for the longer exposure on the smaller cameras and all those on the 104-inch and 114-inch telescopes, which were provided with visual lenses, were slow orthochromatic.

Mr. ABBOTT'S intramercurial camera had numerous points of interest. A strong equatorial mounting carried four large cone-shaped tubes built up of small wooden rods so as to combine great rigidity with lightness. These were covered with light-proof rubber cloth. The four lenses were compound, of four inches aperture and eleven feet focal length. The same clock ran a large mirror on the telescope pier which threw the beam of light into the bolometric room, some ten feet distant. Each tube carried two 24×30 plates so arranged on hinged frames that one plate lay flat against the side of the tube while the other was in position. At the slipping of a catch the exposed plate was drawn up against the side of the tube by springs, and the second as quickly rotated into position, the entire operation occupying only a few seconds. The large shelter, covered within with black cloth, was a dark-room and camera combined, the exposures being made by a sliding curtain at the top.

Cut films were used on the various spectrographic plate-holders, bent to the proper radius against curved guides. The sliding plate-holders were equipped with suitable stops, so that successive films could be exposed with very little time lost in shifting.

Efficient assistance on the day of the eclipse was given by Mr. IRVING, a colporteur of the English Bible Society, who acted as our interpreter, and by Surgeon ODELL, Lieutenant CHASE, and nine sailors from the "General Alava." Accustomed to the discipline of a man-of-war, these intelligent and capable sailors took naturally to the drills preparatory to the eclipse and went through their programmes without a hitch. A break-circuit chronometer sent signals to a telegraphic sounder at each instrument; the minutes were struck on a locomotive-bell.

Only those who have been through similar experiences can realize the labor involved in setting up and adjusting the instruments of a large eclipse camp. Though we were agreeably disappointed to find in this portion of Sumatra a well-ordered colony, and not a tropical wild, there were many needs and emergencies in which we felt the limitations of the island very keenly. We found Dutch of comparatively little value, and learned Malay perforce, for the Dutch Government forbids the use of Dutch by the natives. Labor was cheap,—twenty to forty cents gold a day,—but of poor quality; for all work requiring more skill Chinese are employed. Watchmen were furnished us free by the Government,—two wizened hill-natives, who regularly slept through the night on our barrack porch. In this and other ways we came in contact with the "Heerendienst," or forced-labor system, of the Dutch Government, a much-criticised policy, but one which has certainly produced wonderful results in Java. Our greatest difficulty lay in the climate itself; for it was soon evident that our chances of a fair day were very poor. In such a land as Sumatra, where there are only two seasons,—a wet, and a wetter,—the difficulty lay in finding even gaps in the clouds for the necessary astronomical adjustments.

In all our difficulties, however, we found the Dutch officials ever helpful, kind, and obliging. It would be impossible to say too much of the kindness of the Colonial Government in this particular, its foresight in preparing for us in every way. Free transportation for all freight and baggage and an unlimited pass for all visiting astronomers were not the least of its favors. With every official, from Governor YOEKES to the humblest railroad employee, "Zoneklips" was an "open sesame."

Though it was foreseen that the chances were very poor, a few very good days in May had raised the hopes of all, and it would be useless to try to describe the feelings of the party at Solok as the 18th of May dawned with the sky covered with clouds. To the north a beautifully clear patch could be seen over Lake Sinkarak, too slowly approaching, for it reached us three hours after the eclipse. From computations made by Mr. LITTELL and the writer, the more important data for the eclipse at Solok were—

Contacts.		Solok Mean Time.
I.	May 17,	$22^h\ 47^m\ 31^s.8$
II.	May 18,	$0^h\ 21^m\ 20^s.8$
III.	May 18,	$0^h\ 27^m\ 12^s.7$
IV.	May 18,	$1^h\ 59^m\ 36^s.2$

Duration of total phase $5^m\ 51^s.9$.

Observations by Professor SKINNER with a three-inch telescope and of the first and fourth contacts with the six-inch by the writer agree in placing the observed eclipse about 12^s ahead of the computed time.

At the time of second contact the sky was covered with a layer of clouds not quite thick enough to conceal *Mercury* or *Venus* but sufficient to cut off all sight of the corona except a very narrow rim around the edge of the Moon, and it was with a feeling of the futility of further efforts that we went through our respective programmes. From about the third minute of totality, even the narrow rim of light disappeared; it was impossible to locate the eclipsed Sun visually, and plates taken at this time show nothing but fog. An interesting feature noticed by other observers under similar conditions was the quantity of light still present, reflected by the clouds from the illuminated land beyond the eclipse track. The lanterns which had been provided for a "dark" eclipse were entirely superfluous. It seemed to me personally to be lighter at Solok in mid-totality that at Thomaston in 1900 ten or twenty seconds before second contact,—this though the eclipse path was nearly one hundred and fifty miles wide and we were thirty-one miles from the central line. At Fort de Kock, on the other hand, where the sky was perfectly clear, lanterns were needed, although they were only seven miles from the edge of the shadow.

Thus even the hope of a veteran astronomer that we should be favored either with a clear sky or a pouring rain was not realized, for surely the most mournful part of an unsuccessful eclipse is the hopeless development of the great plates from which so much had been expected. Practically nothing of value was secured at Solok, equipped with what was perhaps the most powerful and representative array of instruments ever set up in a single camp. The prismatic camera secured a good film of the first flash, and some of the faster plates secured the rim of the inner corona, but hazy from drifting clouds. Mr. ABBOTT attempted no bolometric work; while quite a number of stars were made out on his plates taken in the first half of the eclipse with the intramercurial camera, it seems that the conditions prevailing at every camp where instruments of this sort were in operation leaves this problem still open, a question which it was hoped might be definitely settled at this unusually long eclipse.

Better results were secured at Sawah Loento by Dr. MITCHELL and Mr. GRANGER. The clouds here were much lighter, and the spectroscopic results in particular promise well.

Fort de Kock was the only camp on the island blessed with absolutely clear weather, and several excellent photographs were secured by Mr. PETERS and Dr. HUMPHREYS. All other camps had light clouds, though in many cases insufficient to ruin the spectroscopic and polariscopic results.

It took far less time to pull down than to fit up the camp, and several days were then very pleasantly spent in seeing the sights of this exceedingly interesting but little-visited corner of the globe. Several of the party ascended the active volcano Merapi, nine thousand feet high and only a few miles from Fort de Kock; the jungle climb to Pajo, near Solok, affords what is said to be one of the most beautiful views in the East Indies, and to all of us, the native, his customs and peculiarities, his picturesque, beautifully carved and decorated houses, formed a fascinating subject for observation and photography. This central portion of Sumatra is thought to have been the original home of the Malay race. It is now well under Dutch control, and is covered with almost perfect roads, many of them dating from the English occupation of the island, roads which can not be paralleled in any State in the Union. At the north of the island, at Atjeh, the brave and capable Malays have been at continuous warfare with either the English or the Dutch for nearly one hundred years, and only thirty miles inland from Solok one finds the boundaries of the independent native states, to many of which no white man is admitted.

Aside from two weeks spent at Manila, our long trip home was without special interest, and we were very glad to disembark from the U. S. A. T. "Indiana" after nearly six months absence.

The camps of the various expeditions were quite well separated, from the Dutch and English on the coast near Painan to our own camp at Sawah Loento, while on the eastern coast of Sumatra Professor TODD occupied the island of Singkep. Over all this portion of the path the rule was cloudy weather, and it is to be regretted that in such an important eclipse as this one, especially in view of the tropical and exceedingly uncertain weather, the stations were not scattered even more widely. The Dutch were quite anxious that some nation should send its expedition to Borneo or Celebes. The conditions here would have been somewhat more difficult, but in no sense dangerous, and a station or two somewhere in this neglected portion of the shadow-path might have saved the day.

LEANDER MCCORMICK OBSERVATORY, Charlottesville, Va.

THE *LEONIDS*—GRAND DISPLAY OF METEORS AT LOWE OBSERVATORY.

BY EDGAR L. LARKIN.

The usual stream of *Leonids* was observed here from midnight until dawn November 15, 1901. The first meteor was seen at $11^h\ 53^m$ P.M. on the 14th, before the radiant rose above the peaks